Prediction of Percent Retail Product, Retail Product Weight and Hot Carcass Weight From Serially Measured Live Animal Traits

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Summary

A total of 1,072 observations collected over a six-year period were used to develop prediction models for retail product (percentage and weight) and hot carcass weight from live cattle measures. Independent variables used were: ultrasound fat thickness (UFAT), ultrasound longissimus muscle Area (ULMA), age, hip height (HT), live weight (WT), ultrasound-predicted percent Intramuscular fat (UIMF) and breed composition. Pearson product moment correlations between the dependent and independent variables were often significant ($P < .01$, $P < .05$). In the prediction of percent retail product, UFAT accounted for 29 to 42% of the variation. A complete model including all the independent variables explained 20% more of the variation. In the prediction of retail product weight, WT remained a highly significant independent variable accounting for 32 to 78% of the variation. Similarly, WT accounted for 38 to 81% of the variation in hot carcass weight. When independent variables were adjusted to a constant age, models from data adjusted to earlier ages (M-414, M-382) explained more variation than models from data adjusted to a mean age at slaughter (M-448).

Introduction

The profitability of today's beef business depends on economical production of a uniform and high quality end product. In recent years ultrasound technology has become an important tool in this endeavor by enabling producers to measure fat cover, longissimus muscle area, and percentage intramuscular fat in live cattle.

Ultrasound technology provides a unique opportunity to develop a prediction model for traits including hot carcass weight, retail product weight, percentage retail product which otherwise are measured at slaughter. However, a general consensus has not been reached regarding the specific measures to be considered and time(age) of measurement. Hence, the main objectives of this study were to:

(a) evaluate animal measures of live cattle,
(b) develop prediction models for hot carcass weight and retail product (percentage and weight), and
(c) suggest a possible protocol for collection of ultrasound data.

Based on the current stage of analysis, this report covers a preliminary evaluation pertaining to the first two objectives.

Materials and Methods

Source of data

Included in this study were live cattle and carcass data collected from cattle fed at the Rhodes and McNay beef research farms of Iowa State University. A portion of these data were produced from progeny of synthetic sires, and the rest came from Angus and Simmental sired progeny. These cattle were part of a serial scan and serial slaughter project designed to evaluate sex, age and frame size differences in carcass composition.

Each year cattle were identified at birth, fed a diet containing corn and corn silage with a level of concentrate up to 85%, and slaughtered at three age end points. Cattle were ultrasonically scanned between the 12th and 13th ribs three to five times for external fat thickness and ribeye area. Ultrasound measurements were made using an Aloka 500 V unit (Corometrics Medical Systems, Inc, Wallingford, Connecticut) equipped with a 3.5 Mhz, 17.2 cm linear array transducer. With the exception of the first two years, weight measurements were taken during each scan session and hip height and ultrasound predicted percent intramuscular fat (UIMF) values were collected on about 200 progeny.

Cattle were assigned to slaughter groups randomly within sire breed, with the first group being slaughtered at an average age of 423 d or after about three months on feed; subsequent slaughters took place at an average interval of 25 to 30 days. During each slaughter, steers were transported to a commercial facility within next 2-3 days after the last scan and slaughtered according to regular plant practices. Carcass traits collected were hot carcass weight (CARWT), 12-13th rib fat thickness (CFAT), longissimus muscle area (CREA), kidney, pelvic and heart fat (KPH) and chemical percent intramuscular fat (CIMF). Percent Retail Product (PRP) and retail product weight (RPW) were computed from the previously listed carcass traits using equations of Crouse and Dikeman (1976) and Epley et al. (1970), respectively.

Statistical analysis

Analysis of growth: Preliminary evaluation of data was made through analysis of fixed effects on serially measured traits at each scanning session. The main reason for this was to see whether or not such fixed effects as group (breed-frame size) and sex had any influence on the growth of serially measured traits and if so to see when during the feeding period such influences become apparent. Due attention was given to sex and group effects to see if there is a need for the development of prediction models by breed and sex classes. In addition, a repeated measures model was used to see if data pooled over the years describe growth more adequately than the regression of the same traits on an individual animal basis.

Prediction model: For each scanning session Pearson product moment correlation was used to evaluate the degree of linear association between the dependent variables of CARWT, PRP, and RPW and the serially measured traits of ultrasound fat thickness (UFAT), ultrasound longissimus muscle area (ULMA), hip height (HT), live weight (WT) measures, and ultrasound-predicted percentage Intramuscular fat (UIMF). Multiple regression techniques were used to evaluate the percentage of the total variation in CARWT, PRP, and RPW accounted for by a model. That is, at each event, comparison of models was made based on model R^2 and root mean square error (RMSE). All statistical evaluations were made using SAS (1989).

Results

Description of growth

A total of 1,072 observations collected over six years were used in the analysis. The number of slaughter groups ranged from a minimum of one in 1996 at Rhodes to a maximum of four in 1994. Data in 1991 were entirely from progeny of synthetic sires. Except for 1992, there was a good distribution of information over the years for bulls and steers. Heifers were represented in the last two years of the study.

In the analysis of growth in UFAT, ULMA, WT, HT, and UIMF, measures were subjected to analysis of variance by scanning session (Tables not shown here). Results indicated a consistent and significant ($p < .01$) influence of sex effects on UFAT, ULMA, and WT. Group showed a significant ($P < .01$) effect on UFAT and WT. However, influences of these group and sex effects on HT and UIMF were not uniformly apparent.

Results of data evaluation using a repeated measures model are depicted in Table 1. The purpose behind this analysis was to see how well regression of traits on age using data pooled over the years describes growth as compared with individual animal regressions. This was necessary to decide on an age adjustment strategy to be used later in this study. The linear and quadratic terms of age showed a significant ($P < .01$) effect on all serially measured traits. The single different case was for HT measures where the quadratic term was not important. Furthermore, with the exception of UFAT and UIMF, there were significant ($P < .01$, $P < .05$) effects of $\text{Animal*Age}_{\text{linear}}$ and $\text{Animal*Age}_{\text{quadratic}}$ interactions. The interaction terms suggest that the effects of age on these traits varies with individual animal and hence growth in these traits may not be represented by a single equation generated from pooled data. Therefore, regression of serially measured traits on age on an individual animal basis may provide a better representation of mean growth.

The regression of traits on age from pooled data showed a lower R^2 and a higher RMSE as compared with the corresponding values when regressions were made on an individual animal basis. When regressions were made on data pooled over the years, the R^2 values ranged from 0.06 (UIMF) to .40 (ULMA) and the RMSE ranged between a minimum of .25 (UFAT) to a maximum of 65.49 (WT). For individual animal regressions, the R^2 values for UIMF and ULMA were .64 and .87, respectively and the RMSE for UFAT and WT were .09 and 4.2, respectively.

Correlation and prediction models

For most scanning sessions, the correlation of PRP with independent variables was significant ($p < .01$, $P < .05$). The largest, correlation coefficient occurred with UFAT (-.65 to -.54), followed by UIMF measures (-.09 to -.51), and HT (.02 to -.50). The correlation with ULMA was often positive but small. WT measures were strongly and positively correlated with Kg of retail product (.60 to .86) and with CARWT (.66 to .90). The correlations of RPW and CARWT with ULMA and HT data were similarly positive and high. Generally, correlation coefficients increased as a scanning session approached slaughter (Table 2). In the prediction of PRP measures, a model including UFAT accounted for 29% and 42% of the variation when measured at the fifth (S-5) and last (S-1) scan before slaughter, respectively (Table 3.) However, a more complete model including UFAT, ULMA, WT , age, HT, UIMF and breed composition accounted for a maximum of 20% more variation in the dependent variable (S-1), indicating the high influence of UFAT on PRP prediction. In the prediction of RPW from serial measurements, WT remained a highly influential independent variable accounting for 33% and 78% of the variation in S-5 and S-1, respectively (Table 4). However, including ULMA, UFAT, WT, HT, UIMF, and age in a model raised the R^2 to .76 and .95 in the respective sessions.

Similarly, WT accounted for 38% (S-5) to 81% (S-1) of the variation when used as a sole predictor of CARWT (Table 5). When WT, UFAT, ULMA, HT, UIMF, and age are included in the prediction equation, the R^2 increased to 78% and 96%, in S-5 and S-1 respectively.

For all the dependent variables considered and regardless of the prediction model used, the percentage of the variation in the independent variable accounted for by a model seems to increase as the scanning session approaches slaughter. The largest increment took place between S-5 and S-4. Often an increment in R^2 value due to additional information seems relatively large when measurements are done early in the feeding period.

The results of this analysis suggest that CARWT, PRP, and RPW could be predicted from serial measurements of UFAT, ULMA, WT, HT, UIMF and age information. Furthermore, there seems to be a clear indication that these traits could be predicted with reasonable accuracy from a single scan taken during feeding.

In a further analysis, serial data were adjusted to a constant age of 448, 414, and 382-d based on individual animal regressions. These values represent mean ages of cattle at slaughter, the second (S-2) and the third (S-3) scans before slaughter. Data were analyzed using the stepwise regression procedure of SAS(1989). In all cases, a minimum level of significance was set to 10%. The result, of this analysis are shown in Table 6.

In the prediction model for PRP, effects of UFAT, ULMA, and WT were significant ($P < .01$) for all age end points. However, at an age of 382-d, UIMF was included in the model, resulting in a better R^2 than M-448. For all three age end points, UFAT accounted for a larger proportion of the variance in PRP.

For RPW, the best fit was for data adjusted to 414-d of age. WT, ULMA and UIMF, showed a significant($P < .01$) effects at slaughter age. However, the inclusion of UFAT and HT at earlier ages led to increased R^2 for M-414 and M-382. The same trend has been observed in the prediction of CARWT, where models in the earlier ages contained more independent variables and a higher R^2.

The results of this analysis show high model R^2 values when measures are made or adjusted to ages earlier than slaughter. This may be due to several reasons. There could be a problem of extrapolation when data are adjusted to a mean slaughter age of 448 days for individuals slaughtered at a younger age. This situation may contribute to bias and perhaps to a reduction in variability. Based on their work on Brangus cattle, Waldner et. al. (1992) related accuracy in ultrasound measurements of UFAT and ULMA with age at scan. They recommended that animals be scanned for external fat thickness at an age of 12 months and for ULMA at 12 to 14 months. Hence, measurement errors in the later stages of feeding may influence accuracy of age adjustment. On the other hand, the use of breed composition in the prediction model (M-448) seems to improve R^2 for RPW and CARWT. Regression equations have been developed for the respective age end points, and these will be validated on independent data. Therefore, recommendations on these prediction equations and of possible age at scanning are forthcoming.

Implications

The results of this analysis reveal that PRP, RPW, and CARWT can be predicted from serially measured traits with reasonable accuracy. Prediction models for RPW and CARWT may do better when either breed composition is accounted for by the models or breed specific models are developed.

References

Epley, R. J., Hedrick, W. C., Stringer and D. P. Hutcheson, 1970. Prediction of weight and percent retail cuts of beef using five carcass measurements. J An. Sci. 30:872.

Crouse, J. D. and M. E. Dikeman. 1976. Determinates of retail product of carcass beef. J. Anim. Sci. 42:584. SAS institute Inc. 1989. SAS/STAT® User's Guide, Version 6, 4th ed, vol. 2, Cray, NC.

Waldner, D. N, M. E. Dikeman, R. R. Schalles, W. G. Olson, P. L. Houghton, J. A. Unruh, and L. R. Corah. 1992. Validation of Real Time Ultrasound Technology for Predicting Fat Thickness, Longissimus Muscle Area and Composition of Brangus Bulls From 4 Months to 2 Years of Age. J. An. Sci. 70:3044.

Table 1. Influence of some fixed effects on serially measured traits*.

	Traits				
	ULMA	UFAT	WT	UIMF	HT
HYS	11.11**	1.2	15.35**	1.10	.135
SEX	.03	1.98	2.42	1.89	2.81
GROUP	1	3.71*	1.57	6.95**	2.09
ANIMAL(H-S-G)	.84	1	.82	.97	.97
AGE, LINEAR	81.16**	20.11**	88.02**	37.88**	7.71**
AGE, QUAD	59.32**	11.13**	29.58**	37.61**	3.25
ANIMAL*LIN	1.33*	1.16*	1.69**	1.14	1.76**
ANIMAL*QUAD	1.31*	1.15	1.69**	1.15	1.74**

*values are F-statistics for each source of variation.

Table 2. Correlation between dependent and independent variables.

		INDEPENDENT VARIABLE				
DEPENDENT VARIABLE	SESSION	UFAT	ULMA	WT	HT	UIMF
	S-5	-.54**	.16*	-.11	.02	-.15
PRP	S-4	-.55**	-.05	-.29**	-.46**	-.09
	S-3	-.60**	.04	-.17**	-.07	-.48**
	S-2	-.63**	.07*	-.23**	-.50**	-.42**
	S-1	-.65**	.09*	-.21**	.-49**	-.51**
	S-5	-.22**	.33**	.60**	.52**	-.28*
RPW	S-4	.01	.51**	.77**	.52**	.03
	S-3	-.05	.49**	.78**	.75**	-.16*
	S-2	-.09*	.50**	.84**	.33**	-.23**
	S-1	-.11**	.48**	.86**	.32**	-.23**
	S-5	-.05	.28**	.66*	.56**	-.03
CARWT	S-4	.19**	.52**	.83**	.62**	.02
	S-3	.15**	.47**	.83**	.78**	-.03
	S-2	.12**	.47**	.89**	.46**	-.13
	S-1	.11**	.44**	.90**	.45**	-.1

Table 3. Prediction of PRP from serially measured traits.

	Session									
MODEL	S-5		S-4		S-3		S-2		S-1	
	R^2	RMSE	R^2	RMSE	R^2	RMSE	R^2	RMSE	R^2	RMSE
UF	.29	2.61	.30	2.59	.36	2.40	.40	2.33	.42	2.78
UF+UA	.40	2.39	.36	2.47	.39	2.34	.43	2.27	.45	2.22
UF+UA+WT	.21	2.49	.39	2.34	.41	2.23	.50	2.23	.53	2.12
UF+UA+WT+HT	.41	1.93	.47	1.38	.41	1.98	.54	1.61	.58	1.72
UF+UA+WT+HT+UIM	.45	1.89	.52	1.38	.43	1.94	.55	1.63	.59	1.72
UF+UA+WT+HT+UIM+AGE	.45	1.90	.53	1.36	.44	1.94	.56	1.62	.59	1.72
UF+UA+WT+HT+UIM+AGE+BC	.48	1.93	.61	1.31	.50	1.87	.61	1.56	.62	1.68

BC = Breed Composition (covariate)

Table 4. Prediction of RPW (kg) from serially measured traits.

	Session									
MODEL	S-5		S-4		S-3		S-2		S-1	
	R^2	RMSE	R^2	RMSE	R^2	RMSE	R^2	RMSE	R^2	RMSE
WT	.33	19.46	.65	15.38	.68	14.22	.77	12.52	.78	12.14
WT+UA	.42	17.60	.67	14.26	.74	12.60	.76	12.88	.79	11.86
WT+UA+UF	.48	16.72	.70	14.68	.75	12.28	.76	12.76	.80	11.80
WT+UA+UF+AGE	.50	16.46	.71	14.32	.77	11.84	.78	12.50	.95	11.80
WT+UA+UF+AGE+HT	.76	10.42	.83	9.56	.86	9.06	.94	6.74	.95	5.84
WT+UA+UF+AGE+HT+UIMF	.76	10.52	.84	9.56	.86	9.10	.94	6.82	.95	5.78
WT+UA+UF+AGE+HT+UIMT+BC	.76	10.62	.85	9.20	.87	8.74	.94	6.46	.95	5.52

BC = Breed Composition (covariate)

Table 5. Prediction of hot carcass weight (kg) from serially measured traits.

MODEL	Session									
	S-5		S-4		S-3		S-2		S-1	
	R^2	RMSE	R^2	RMSE	R^2	RMSE	R^2	RMSE	R^2	RMSE
WT	.38	34.58	.70	27.19	.71	25.31	.78	22.63	.81	21.60
WT+UA	.47	31.45	.72	26.61	.77	22.05	.77	23.78	.81	21.53
WT+UA+UF	.49	30.78	.73	26.44	.77	22.06	.77	23.66	.81	21.32
WT+UA+UF+AGE	.53	29.82	.74	25.58	.79	21.02	.79	22.79	.81	21.32
WT+UA+UF+AGE+HT	.78	17.76	.84	16.81	.87	15.87	.96	10.22	.96	9.71
WT+UA+UF+AGE+HT+UIMF	.78	17.78	.85	16.80	.87	15.96	.96	10.32	.96	9.71
WT+UA+UF+AGE+HT+UIMF+BC	.78	18.01	.85	16.48	.88	15.64	.96	9.98	.96	9.55

Table 6. Results of stepwise regression analysis.

M-448			M-414			M-382		
Effect	P-R^2	M-R^2	Effect	P-R^2	M-R^2	Effect	P-R^2	M-R^2
			----------PRP----------					
UFAT	.366	.366	UFAT	.423	.423	UFAT	.434	.434
WT	.020	.386	WT	.029	.453	WT	.036	.470
ULMA	.026	.412	ULMA	.051	.504	ULMA	.021	.490
						UIMF	.012	.503
			----------RPW----------					
WT	.621	.621	WT	.706	.706	WT	.668	.668
ULMA	.051	.672	ULMA	.050	.756	UFAT	.074	.741
UIMF	.009	.681	UFAT	.037	.793	ULMA	.021	.762
			UIMF	.006	.798	HT	.014	.776
BREED		.73			.82			.78
			----------CARWT----------					
WT	.659	.659	WT	.771	.771	WT	.738	.738
ULMA	.034	.693	ULMA	.0264	.797	UFAT	.031	.769
			UIMF	.013	.811	ULMA	.008	.777
						HT	.011	.788
BREED		.73			.82			.79

M-448 = model based on 448-d adjusted data.
M-414= model based on 414-d adjusted data.
M-382 = model based on 382-d adjusted data.
P-R^2 = partial R^2
M-R^2 = model R^2